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ABSTRACT

The greatest future impacts of the computer communications technology upon engineering education may exist in its capacity to manage total systems and to extend education beyond current campus borders. Computers can guide learners, professionals, and agencies in education to methods maximized to attain their goals. Sophisticated information processing should result in more efficient decisionmaking processes, more relevant instructional management tools, and increasingly effective manpower-solving procedures. Such potentials should be used in ambitious, far-reaching procedures to affect present-day education, principally by providing accountability and evaluation measures for educational constituencies and by extending educational sites. Once operative, useful information will be available as to what is or is not effective. The criteria must be useful and acceptable to system users, not imposed "a priori" by systems designers. Within the next 25 years, computer graphics communication systems can have universal applications and be an absolute necessity. Without careful planning and intelligent application of this technology, however, results are unlikely to fulfill the potential. To confront this vastly changing world, individuals must learn to use the very tools that are creating the changes. No aspects of education will remain immune to changes created by developments in these fields, which bring both problems and opportunities. (Author/LMM)

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FUTURES:
THE EFFECTS OF EMERGING COMMUNICATIONS TECHNOLOGIES UPON EDUCATION.

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A B S T R A C T

FUTURES: THE EFFECTS OF EMERGING COMMUNICATIONS TECHNOLOGIES UPON EDUCATION

The greatest future impacts of the computer communications technology upon education may very well exist in its capacity to manage total systems and to extend education beyond the borders of present day campuses. The computer can guide the learners, professionals and agencies involved in education to methods maximized to attain their goals. Sophisticated information processing should result in more efficient decision making processes, more relevant instructional management tools and increasingly effective manpower-solving procedures. Such potentials can and should be used in ambitious and far-reaching procedures to affect present-day education, principally by providing accountability and evaluation measures for the various constituencies concerned with the education process and by extending educational sites. Once operative, useful information will become available as to what works or what does not -- where gains occur and where they do not. The criteria must be such as to be useful and acceptable to the users of the system -- not those imposed "a priori" by systems designers.

Within the next twenty-five years, the computer graphics communication systems can become universal in their applications and an absolute necessity in the world in which we live and work. Without careful planning and intelligent application of this technology, the end results are likely to fall short of the potential offered. To confront this vastly changing world, we now have to learn to use the very tools that are changing our lives so quickly and more bold than ever before. There are no aspects of education that will remain immune to the changes brought on by developments in these fields. They bring new problems. They also bring incredible new opportunities.

One suggested schema delineating use of information technology is presented.

* * *

10/83

The recently published "Informational Technology and Its Impact on American Education" by the Office of Technology Assessment of the congress of the United States, draws two basic sets of conclusions:

1. The so-called information revolution, driven by rapid advances in communication and computer technology, is profoundly affecting American education. It is changing the nature of what needs to be learned, who needs to learn it, who will provide it, and how it will be provided and paid for.

2. Information technology can potentially improve and enrich the educational services that traditional educational institutions provide, distribute education and training into new environments such as the home and office, reach new clients such as handicapped or homebound persons, and teach job-related skills in the use of technology.

The first premise is obviously happening, and meaningful success nationally and globally of the second basic conclusion lies in your hands.

Your decisions will affect the capacity of the educational providers in meeting their changing mission.

Futurists herald humankind and machines as destined for an incredible and marvelous merger. The machines of which they speak are the computers, ultimate tools either in their own right or controlling other devices. Computers have become smaller; their capacity grows greater; and the humanitarian applications of these astounding devices are staggering. We are being hurled out of our world, a comparative stone age in its technology, into a new era. The propulsion system is our own intelligence operating in what is becoming a computerized universe that functions in speeds of trillionths of a second. If Guttenberg had been here to invent his technology as recently as 1960, the world would now be learning to read. Goodby Guttenberg, for we are caught up in social transitions as a result of the computer that will make all past revolutions pale.

The next quarter century of microelectronics will yield enormous resources for the research practitioner. Without intelligent application of the new devices, the end results may be less than the inherent potential. Within the next twenty-five years, the systems can become universal in their applications and an absolute necessity in the world in which we live and work. Educators can now create an environment, carefully managed, in which creative thinking; visualization of effects and their causes; the assumption of varying perspectives toward human

knowledge and culture; algorithmic treatments of stored information, including the instantaneous sharing, manipulation and display of data; and the enhancement of an individual's personal needs in the information age -- are all now possible within attainable logistic and economic parameters.

We all hope to improve the quality of life through the educational enterprise in which we are engaged and, hopefully, the subsequent impact on society that derive from our professional life. Coming into these lives, the computer is now a device to control and disseminate information and can even intervene in our very life processes as a regulation device. From behemoths 40 years ago that filled buildings twice the size of this one, we have moved to a million-fold increase in the computer's information processing capacity just since 1950. Some current computers exist in total on one microscopic chip and fit, in total, within a standard-sized paper clip. These are beginnings. The Japanese have announced a crash program to produce a new generation of computers - a machine quasi-human in its capacities, capable of speech comprehension and generations, and with a capacity for an artificial intelligence of high order. Whether or not they do so, the research is on. We have taught the computer to compete at dazzling speeds and to do rudimentary reasonings. We have been unable to give it the basic qualities that make the human spirit and mind unique - the power to emphasize, to judge emphatically and to think, react, and judge from a vantage point of love for fellow human beings. You, all

of you, will never be replaced by our ultimate machines, for these human qualities are the unique properties of humankind. Yet, through your efforts you can contribute to causes which enhance these very properties.

Whatever courses we embark on in the future, essential changes influenced by the computer have already affected the most fundamental aspects of every level of our society and its enterprises - arts, video film, work, education, law, medicine, travel, politics, our homes and even aspects of our personalities and human relationships.

Computer literacy will be the educational requirement of the 1980's and 1990's. Such literacy will be an essential to the student of these decades, yielding a capacity to communicate with and through the computer. It will be as fundamental to his economic survival as reading, writing, computing or ability to use the present day communications channels.

If all of this is true, why should we not have the same advances in engineering technology and engineering education as we have had in other fields? Remember, our children are now born to a society undergoing the most pervasive and important revolution in the history of mankind: - the information revolution - and today's decision makers must face the challenge of providing an educational system <u>that is most effective</u> within this new information environment.

Some early alchemists spent entire lives in unsuccessful efforts to transform mundane elements and compounds into precious metals. Their goals have been met, according to some present day wags, in these modern times.

OPEC was first, converting oil into gold. The semiconductor manufacturers, over virtually the same time frames, discovered how to perform a similar miracle with a form of sand, silicon dioxide. The large scale chips now produced are inexhaustible fonts of gold for those who learn to mine and therefore use the endless variants of products produced.

Among the more dramatic applications of the chips are the continuing evolutions of increasingly powerful and ever less expensive computers. Two decades ago, computers came with two principle characteristics -- they were big in size and big in price. Arrival of the early large scale integrated (LSI) chips marked the introduction of minicomputers. Suddenly, computers could be purchased for thousands of dollars rather than millions.

About a decade ago, coincident with the movement to vary large scale integrated (VSLI) circuitry, the trend toward the personal computer began. Computers began to appear everywhere: in the homes and/or offices of the hobbyists, executives, educators, lawyers, doctors, secretaries, et al, for use by people many of

whom had seen computers previously only in the media. For many, the personal computer in the home, school and office was an easily attainable reality.

Like the rush of the bygone era's population into the Yukon or California, the word spread. The computer was the map to this lodestone and the gold to be found was in the software that made the computer the key. Whatever the applications -- heuristics, electronic mail systems, word processors, graphics, intelligent terminals -- all were part of distributed data processings that were in turn only a subset of emerging communication technologies.

To confront this vastly changed world, we have to learn to use the very tools that are changing our lives so quickly.

A quantum leap is fueled by the microchip. This tiny piece of complex electronic circuitry has been called the creator of the information society; it is behind the most recent revolution in human communication.

The Phi Delta Kappa Study - Education for a New Millenium, describes four distinct revolutions in human communications

> The first permitted the species to transfer knowledge from one generation to another. This was the human phenomenon of complex speech.
>
> Writing was the second revolution allowing persons to transfer information beyond the face to face situation. This was augmented exponentially by the third revolution...
>
> The invention of movable type... giving far greater numbers of persons access to information.
>
> It is the fourth revolution, though, in human communications history ... still in its early stages ... the silicon chip revolution, which will have the most profound and rapid effects upon our society.
>
> It makes us the information society. It makes the educator an aristocrat within such a society.

In The Silicon Age & Education (Phi Delta Kappan, January 1982), Harold Shane points out that in 1980 those persons in the work force who handled information and dispensed communication in its

many forms constituted 50% of U.S. workers, far outstripping other occupations.

On a global scale, the increase in satellite television transmission in just a fifteen year period has increased dramatically.

Information is now a commodity to be accessed in education and bartered in the market place. Processed into formats that are distributed via radio, television, microelectronics, the computer, and other evolving electronically related miracles, information handling costs have not reflected the price escalations of most of the other commodities distributed in the world's trade exchanges. In fact, they have dropped sharply, in some cases as much as ten-thousand fold in the last twenty years.

MINIATURIZATION techniques used to etch integrated circuits on a chip -- boggle the mind. You are familiar with analogies that illustrate the power of the chip, viz.:

The first digital computer cost half a million dollars, weighed 30 tons, and was the size of a house. It used over 18 thousand vacuum tubes requiring one hundred and thirty thousand watts.

Today we etch 60-70 thousand vacuum tubes equivalent on a microchip. The result?

> "A 1945 all-tube computer capable of doing the work of a present day table-top computer would have had to be the size of New York City; it would have required more power than the whole of the city's subway system." (Phi Delta Kappa, January 1982)

The future result is predictable.

Today, computers on a chip, coupled to the multi-faceted capabilities of telephonic equipment, are playing a major role in advancing information processing. The integration of miniaturized computers into communication equipment is commonplace. One result is the avilability of low cost, stand alone intelligent terminals, designed with integrated microprocessors, computer memory and graphic display capabilities. In education, microprocessors available at a minute fraction of the costs of earlier computers of equivalent powers, permit an expansion of computing and communications simultaneously. In the simplest networking applications, microcomputers can communicate over conventional telephone lines. In the most sophisticated applications, such terminals will interact into a global communications network via satellite.

The global potential is there; but what of the here and now?

Our Research and Development activities at New York Institute of Technology have given us the opportunity to investigate and develop instrumentation for the educator, the artist, the architect, the researcher and the software developer to use most effectively.

DEMONSTRATION

The visuals shown are examples of the interfaces possible between electronic, video, and computer technologies used to produce computer graphics at New York Institute of Technology.

Inherent in the presentations are startling tools for the communication specialist, the instructional designer and the researcher. These pictures were produced from beginning to end without conventional cameras or animation stands; ... without animators to do customary intermediate drawings; ...without the painting of conventional cels; ...and without the technical constraints of past practices traditionally used in the assembly of complex animated images.

Most of these pictures were generated by the computer and all manipulated by it. At times, only a scientist's mathematical algorithm was needed to produce finished pictures with no additional human intervention other than the computer and video technicians manning the equipment.

The examples include: multiplaning done by the computer, ... the use of multiple moving objects, all with different textures, for a variety of surfaces, all applied in perfect perspectives within the multi-dimensional moving picture; ... and the blending of Computer Science and Art. The capacity also offers new ways of presenting data through computer graphics. Since all of these images were made through computer software, consider the implications on software engineering or engineering technology as a field of specialization.

For education, there are many technical forces which will influence change. The major technical systems include:

1. BROADBAND COMMUNICATIONS: These systems are capable of transferring a very large number of visual or audio electrical signals to allow any kind of educational transmissions to audiences at almost any distance. Coaxial cables, microwave, satellites, and lasers, give a capability to structure large numbers of telecommunication networks, with almost unlimited capabilities. These networks could tie public and private educational institutions together and feed information directly into the homes.

2. COMPUTERS: The great strength within this technology is its capability to process vast amounts of information to the user. Central time sharing and/or the use of mini and micro computers will make available to the educator greater ranges of access to computer projects. (Calculators are included in this category.)

3. MATHEMATICAL MODELING: Complex educational - economic - social systems can be structured through mathematical simulation. When coupled to computer capacities, an extended range of information becomes available.

The computer, together with modeling, permits rapid access to huge amounts of information and gives its user the capability of manipulating the data in many ways. The computer is specially effective in analysis and portrayal of statistical data. It is equally effective for games and simulations allowing users to change the values of multiple variables in a given problem and to observe the results of such changes quickly.

Laboratory simulation by computer is one of the newest extensions of educational technology. Entire laboratory experiments, sometimes in areas that would be prohibitive in normal environments because of space, costs or hazards, can easily be replicated by computer simulation. Virtually any scientific or technical subject can find useful computer laboratory

simulations. The process can be surprisingly like the real environment. The best part is there is no glassware to be cleaned, no breakage fees to be paid and no pilferage--except sometimes of the newer micro computers themselves. The level of student interaction with the program is optimum.

4. VIDEO REPRODUCTION: The capacity to store in compact form motion pictures on video tape decks or videodiscs for replay at the convenience of the student coupled with broadband technology, offers promise of combining video and computer technology to giving virtually unlimited systems for transferring moving pictures of digital data. We can, through this combination, send to any audience any amount of educational programming with illustrations and sound. Further, video tapes or videodiscs do not even require a transmission system, needing only transportation to move from the originator to the point of playback or from one point of playback to another.

5. BOOKS & GRAPHIC DEVICES: The availability of inexpensive copying devices and the breakthroughs in graphic techniques have enhanced the use of one of education's major visual arts, the book. The recent proliferation of paperbacks is an example of improved print technique graphic capabilities.

6. MINIATURIZATION: Microfiche Technology now allows a substantial area of minaturized images to be placed on transparent materials to be used by anyone seeking information at their convenience through enlargement on either a reading machine or reproduction onto a piece of paper. An entire major encyclopedia volume is presently available in the form a single fiche measuring 3 X 5".

Never before in human existence has so much information been generated, to be coded, systematized, categorized, and stored for the human race to utilize. In the past there were time lags of years between scientific and technological advances and their application to social problems, but today acute research questions demand immediate access to information. A composite of the technologies just described, promises solutions.

Think of the contexts you consider appropriate for your institution. Now, consider the rapidly changing nature of your institution as it is called upon to serve in a period of scarcity and open competition, a period when the pool of traditional age students is expected to shrink by 26% and 15% of existing colleges are expected to fail or be transformed through mergers and acquisitions. It is already clear that the climate and the management of higher education are changing daily as colleges become more future oriented, sharper, leaner, and more attuned to

the hazards and opportunities that lie outside their walls. We must broaden our horizons.

Let me emphasize that the microcomputer, growing in power and capacity exponentially, must do more than provide management and managerial information above. Let me hypothesize the need for a total educational accountability system for the future, one capable of answering the myriad of questions you will want or need to have answered.

OVERVIEW FOR THE ENGINEER/ENGINEER TECHNOLOGIST

The greatest future impacts of the computer communication technology upon engineering education may very well exist in its capacity to manage total systems and to extend education beyond the borders of present day capacities. The computer can guide the learners, professionals and agencies involved in engineering education to methods maximized to attain their goals. Sophisticated information processing should result in more efficient decision making processes, more relevant instructional management tools, and increasingly effective manpower-solving procedures. Such potentials can and should be used in ambitious and far-reaching procedures to affect present-day engineering education, principally by providing accountability and evaluation measures for the various constituencies concerned with the education process and by extending educational sites. Once operative, useful information will become available as to what

works or what does not -- where gains occur and where they do not. The criteria must be such as to be useful and acceptable to the users of the system -- not those imposed "a priori" by systems designers.

With the advent of large scale computerization, the transformations taking place in the field of education now include these principal types of patterns:

1. Computer usage designed to yield effective evaluation, accountability and management information to constituencies concerned with the educational system;

2. Guidance related to education mission;

3. Use of the computer (a) to "teach" and/or problem solve (computer assisted instruction); (b) to manage and/or monitor varied subject matter content (computer monitored instruction);

4. Training to prepare personnel to be computer literate.

Additional approaches using computer/communication systems that will be reflected in the forthcoming decade already include:

1. Eyeglasses and Mirror Concept - Computer lets learner see more clearly what he or she is doing and "reflects" to an observer the progress being made.

2. Computer as an articulate expert - Carefully doles out information only at the request of the learner.

3. Low Cost Simulator - Low cost computers with graphic facilities, proven very successful with students.

4. Computer as a menagerie - For young children. Uses rudimentary graphics of things like balloons, animals, etc. that are familiar to young children and teaches spelling, grammar, the concept of fractions, etc., using these presentations. The universities are heavily involved in such research.

5. Computer as word processor and electronic mailer - The usages are as varied as imagination, from the teaching of language to the extension of the classroom to any locale.

6. The introduction of computer artificial intelligence capabilities to enhance software engineering.

Frequently little, if any, use is made of successful innovative educational practices, models and methodologies--due to a lack of information and transmitted professional know-how. The usual

educational establishment is bereft of sufficiently rapid feedback on which to base corrections for deficiences on the basis of any combination of the following: inadequacy of environment, resources and methodologies; mismatch of teacher and learner; insufficient prerequisites and preparation; poor learner attitudes; or the innumerable other tangible and intangible factors which influence the effectiveness of the learning process. It is hardly surprising that talent and funds are eroded by inefficiency. Educational planners hope the sophisticated capabilities of modern technology can reverse the pattern.

A massive, computer-based information system effort to identify those means which provide the most usable information and to develop an evaluation system that will optimally relate the best procedures is one way out of the current crises.

Sound principles of educational accountability dictate that we stop bending all our efforts to assembling data and that we begin the task of genuine assessment.

A workable educational accountability and evaluation system must provide information for each one of its prospective users; an individual must be supplied with evaluation data that is explicitly relevant to the particular facet of the educational endeavor he wishes to examine. Clearly, not everyone perceives the educational enterprise from the same perspective.

One local PTA community group may ask about Ivy League college acceptance rates for their school; another may ask about community college admissions levels; the English teacher may wish to know the mean reading level of the tenth grade students in his school district; the college president may be desirous of information ranging from personnel budgeting procedures to the relationship of the per pupil cost of education, in specific academic programs, to subsequent academic performance and attrition. An evaluation committee concerned with career education may wish to ascertain the effects of past curriculum changes on the post-graduation performances of former students. Students may desire guidance information. In essence, an accountability information system which is not flexible enough to supply a wealth of information, to different groups, in formats they will accept, is simply not usable.

A malleable system design, a readily accessible data base, and information for evaluation of education on any dimension relevant to the users of a specific system are essential for complex explorations of the educational process. These requirements necessitate, then, that the information system must be broad-based, be free of the attitudinal and value biases of its designers, and yet be sufficiently flexible to be responsive to the attitudinal and value biases of its users.

Simple information, such as a comparison of individual types of student achievement against a national norm, has been accessible

for some time. Evolving technologies, however, have facilitated the growth of information systems capable of more sophisticated evaluations. With such a system, complex new endeavors are possible; one could, for example, look at amalgamations of variables which previously were not subject to direct evaluation due to confounding effects. Now one can begin to record effects of environmental and strategic variables, in combination, on the people being served by a given educational enterprise. The results of such a systematic data analysis do not imply any superlative or mandatory pedagogical procedure, but they do provide guidelines on the effects of specified combinations of variables on performance in the educative process.

An information system such as that described above can serve to establish evaluative baselines that are currently lacking in the educational profession. Evaluation is impossible without such guides; an information system can supply the criteria for evaluators seeking to explore educational processes.

An educational program is about to be evaluated. What is to be the criterion of judgment? Will it be the length of learning time? The cost per pupil? The retention rate? In times of war, rapid military training in some areas is critical. Then, assuming equivalencies of learning and retention, it is time as opposed to money that assumes an evaluative priority. Similarly, the ratio of pupil-expended time to pupil successes to dollars spent might be the major criterion for evaluation of an adult

educational program (perhaps the attrition rate is high because the length of time required for completion of the program is too lengthy to meet the pressing needs of an active adult). Again, in any specific case, what is to be considered too much time or too much money? At present, these judgments are often based on the intuitive perceptions of an evaluator. An information system, however, could provide a baseline. The evaluative baselines generated by an information system will not serve as overnight cures to educational ills, but will supply clues to what can be considered adequate performance in specified educational situations.

By way of analogy, let us consider two doctors. One resides in upper Sutton Village and the other in Mining Town. The rate of tuberculosis, extremely low in Sutton Village, is substantially higher in Mining Town. Thus, the incidence rate of tuberculosis "acceptable" to the doctor in Sutton Village is less than that of the doctor in Mining Town, where the susceptibility levels to TB are higher as a result of environmental conditions. Furthermore, the doctor who permitted a small unchecked increase in the TB rate of Sutton Village would likely find himself in greater difficulties with the local authorities than would his counterpart in Mining Town. Clearly, the accountability of the two doctors in this analogy is dependent upon baseline conditions relating to the mean incidence of that disease in their environments. Similar analogies might be drawn for the surveillance of maternity cases. An excess of mortality cases

might result in an official evaluation of the doctors' medical prowess. The baselines for comparison, however, could well vary with the locale of practice.

It is equally essential that teachers, as professionals, be held accountable for an excess of "mortality cases" within the schools. Yet what are the baselines? What can the average teacher accomplish with a class of specified number, age, sex, racial, religious and socio-economic characteristics found within a given environment? The information system can provide the knowledge of baselines structured under specific conditions that will facilitate evaluation and accountability in the teaching profession, and in other educationally related occupations.

CHARACTERISTICS OF THE ACCOUNTABILITY DESIGN

Many colleges, particularly the career and community colleges, have gone to virtually open educational enrollment practices. Inherent, therefore, in the projected design is the belief that it is not enough to give an academic education to a small proportion of our most apt high school graduates, nor is it enough to provide the more marginal student with an opportunity to sink or swim in a college environment; for all too often this merely allows another experience in failure. What appears to be needed are new instructional techniques which are sufficiently

powerful to enable a much broader range of students to cope more successfully with diverse curricula than has been true in the past.

Two continuing broad phases must characterize the systems evolved. The first is to develop an educational format which is appropriate to the needs of a relatively heterogeneous student body -- and to do this through an instructional management program, employing resources and guidance growing out of modern educational methodologies. The second phase implementation of such a model must make it responsive to the needs of users.

Clearly, the aims and activities are ambitious and difficult to obtain. Hope of success rests largely on the belief that by instructional management through systems, analysis, an operational program which realizes significantly greater efficiencies than currently attained is possible. As soon as a model can truly be made applicable to a much wider range of students (the regular, the professional in need of upgrading or updating, the advanced, the geriatric, the pre-school, etc.), its significance for all education will increase materially. Further, if the system is inherently self-improving, and is flexible enough to include interaction with environments not always directly considered as influencing education (industry, labor, community, etc.), then new dimensions in education and training may be anticipated.

The model envisions providing several desirable outcomes:

1. A generalized self-improving model for instructional management applicable to a heterogeneous population in diverse environments.

2. A test bed applicable to post high school populations, including academically and economically disadvantaged youngsters in occupationally related programs.

3. A sharper focus on unanticipated needs for 1. and 2. above, resulting from empirical feedback following implementation.

4. A design model which can be a basis for a total system applicable to the general needs of education.

5. A design model which can test alternative routes of higher education, in consortiums with public and private sectors not normally fully utilized, to advance efficiency and reduce costs of higher education.

6. A design model which can serve as a basis for the development of accountability and evaluation guidelines against which there may be established higher standards of efficiency for given dollar expenditures.

7. Provide guidelines for performance contracting and independent educational accomplishment audit.

Accountability in a system presupposes both obvious and subtle components. It demands that both the system's interactions and its component operations be made available for scrutiny, so that verification of outcomes is possible. It implies that the outcomes be related to the objectives to determine the extent of achievement. It suggests that dynamic forces be operated to correct deficiencies and improve the system. It insists that the system interact with the environment because, even in minimal interaction, the environment includes the observer to whom the accounting is provided.

ENGINEERING; ENGINEERING TECHNOLOGY

In this transitional age, we see young children already at home with the computer. Concurrently, astounding technical achievements are reported virtually each day. (As one example, the "Technology Today" issue of August 4, 1983 reported research that permitted a paraplegic to walk, with a computer worn on the hip to pulse electronic signals past the damaged spinal cord!) We are comfortable with smart terminals, electronic banking, space shuttles, robots and flex-time, all competing with an

increasing search for individual identity on the part of our students. There is an increasing impact of different forces resulting from the acceleration of technological change.

There is another vital consideration that impacts upon us beyond the aforementioned potentials of computer/communications, dazzling technologies and the educator's abilities to predict student achievement related to institutional quality with greater precision. The scale of social change that is bringing us an information based society will, in many futurist's opinions, supplant our current industrial society in the same manner as the industrial revolution displaced earlier agriculture civilizations. If true, and I for one believe it to be so, this may well be a time for professionals in engineering and engineering technologies education to organize major transitions in our curriculum and delivery processes to be reflective of emerging societal needs. Just as engineers and engineering technologists spend their lives either in restructuring older designs or designing totally new systems to yield better, more powerful, more accurate, more efficient and more effective variants of their delivered products, so can we educators move to accomodate the changing technical skill requirements of an ever larger population that requires retraining after initial education. We have an opportunity not only to keep the best we have had in the past, but to move forward, boldly, with new educational organizations that meet more closely the requirements of our emerging new society.

The pundits forsee a work world directed away from manufacturing economies based on steel, automotives, textile, clothing and such, to one based on communications, genetics, aerospace, environmental technologies, optics, lasers, bio-technologies, robotics, fluidics, computer software, telecommunications, video and the ever burgeoning field of electronics. Already these most significant additional technologies of the 80's and 90's are beginning to emerge into our educational systems to include courses dealing with computers, artificial intelligence, SVLSI (super very large-scale integrated circuits), interactive computer graphics, computer integrated manufacturing, computer aided design, optical computers and processes (including holograms and lasers), digital communications, satellite oriented communications, high definition television, robotics, microrobotics, light wave systems and the high level software necessary for the operations of all of the above.

The rapid rate of change in the technologies bring great stress to the current educational systems and suggests we must become more flexible in terms of our educational designs to alleviate these stresses. Some of the requirements are obvious. There is a need for increased quality in literacy prerequisites in mathematical and in science preparation in both primary and secondary school levels, all as prerequisite keys to engineering and engineering technology study. Yet, following the restructure

of prerequisite education , there exists the opportunity for new kinds of partnerships now practical between business, industry and education.

We should design and try some powerful models for engineering education. One starting point could well be to solve the classic incongruities between engineering technology and engineering curricula that have existed for four decades. The current situation is ambiguous and leads to dissatisfaction by all the parties involved, be they professional engineers or engineering technologists.

We have often pictured preparation for engineering and its support positions as a triangle whose bottom areas are filled with occupational courses; whose intermediate area is delineated as engineering technology teaching and whose upper apex area is that of the professional engineer. Yet the educational relationships between these three are often disfunctional.

In an era where the 12th year of education has come to be questioned in terms of its value to many high school seniors and where we have already filled our high school curriculum with college level programs it becomes feasible to consider an educational program for technologists that could start at the 11th and 12th year, or earlier. It could encompass much of the content now associated with engineering technology associate degree programs now given within community colleges and give

these institutions earlier access to such students. It can allow follow up bachelor of technology programs or equivalents in an accelerated format. It can also include all necessary necessary educational prerequisites for engineering for those students choosing to continue towards the highest levels of engineering preparation.

The school year could easily become a calendar year in length through the umbilical connections of computer technology connected into the resources of existing engineering and engineering technology departments.

Home terminals could give the student such access at times beyond those of formal school. Certification by competency criteria could be made. With exit competencies at levels equivalent to the present baccalaureates of technology possible, the student certified and skilled in engineering technology could enter cooperative engineering work study programs or traditional engineering curricula so long as their demonstrated competencies met the entrance requirements for such programs. The benefits to the student, the institutions, to industry and to society would be enormous.

This paper does not argue that such a transformation is the only route or even the most desired route. Rather, it suggests that the very visible successes of the graduates of our engineering

and engineering technology teaching centers in the last decades in structuring new technologies that dazzle our minds be turned towards new designs in education. These, in turn can be examined with the view towards solution of present day problems in our engineering related teaching centers.

Some immediate benefits result from such a concept. A broader spectrum of our present high school constituencies could be educated for the emerging new industries as well as the traditional industries that have provided jobs in America for generations. The artificiality of current distinctions between engineering and engineering technology would disappear, for one would be an entrance prerequisite for the other. Then, through the use of computer and communication technologies we could produce new forms of cooperative work study programs in new organizations of academic "flex-times".

Today, in many institutions of higher education, uncertainty, criticism and prophecies of doom are rampant. It makes sense to set aside non-constructive attitudes and concentrate instead on creating productive and innovative approaches that will augument success in the decades ahead.

Engineering institutions have an opportunity to change considerably from present practices, adapting to new markets derived from fresh links between institutions, faculties, students and the communities of government, business and

industry. The boundaries of the classroom can be removed and at the same time the resources available to the student enhanced in unlimited ways.

Nowhere is there a better opportunity to use this information age than in engineering technology and engineering education. The more important of the trends have already been pointed out, specifically the incredible increments in computerized communication, simulation and graphic technologies; the abilities to monitor aspects of performance achievement of a learner; the development of a rapidly changing "third-wave" society with new mores for its work force; and, the ending of the traditional university monopoly on higher education. With respect to the latter, there are now increasing numbers of educational programs in business and industry that offer integrated programs leading to degrees offered by the very corporation which is the employer. In increasing numbers of cases such as the Arthur D. Little Management Institution, Wang Institute, the Armed Forces and others, college degree programs are available outside of the formal institutional structure.

There is also an increasing recognition and certification of experiential learning by colleges and universities. More than a thousand accredited instituitions of higher education have in place evaluation criteria to permit award of credit to students for learning gained by job experience.

There, too, are increasing numbers of consortia linking colleges and universities to business and industries. Some university consortia such as the projected National Technological University, offer pooled resources for off campus students towards engineering degrees given through nontraditional educational delivery systems. Entire degree programs are projected through combinations of computer and various aspects of video, whether recorded on video disks or cassettes or transmitted live. It seems reasonable to forcast that higher education institutions in the decades ahead are more likely to be less traditional than their counterparts today. They are also much more likely to permit alternative routes to the attainment of students degrees than those now in place. The universities of tomorrow will certainly continue fundamental research and the dissemination of knowledge. It is likely that they will be inevitably impelled towards more flexible, novel programs to solve the problems now confronting them.

Today, the engineering and engineering technologies instuitions are concerned with finding appropriate pools from which to draw their student bodies. They are equally caught up with the problems of recruiting capable faculty and administrators, whose very skills are often sought after by non-academic competitors willing and able to pay scales more lucrative than most schools are prepared to meet. They must solve the dilemma of maintaining up-to-date, expensive state-of-the-art equipment for the students

to work on. There is also the need to deal with an understandable desire on the part of their students to exploit new knowledge and skills once acquired, to earn while they learn and to find solutions easing the burdens of tuition and living accomodations.

The suggestion is made therefore, that the very institutions that exist to teach the methodologies whereby the new are designed, could benefit immeasurably by structuring patterns of flexibility which as alternatives to present practices permit, by student choice, time compressed or time expanded programs; and, industry education consortia using the telematic interconnections of our society in new organizations of work study for cooperative education. The quality of the educational programs which allow students (and faculties) to spend much longer times in industry sites and employment, would be valuable and achievement of the students can be made by measurement of outcome criteria. The combinations between college and industry can then become infinite.

The responsibilities of the faculty in such arrangements would remain constant in terms of their responsibilities to teach, to counsel, to do research and to publish. What will change in a third wave society, is the ability, beyond present day measures, for the individual professor to consult and to work for

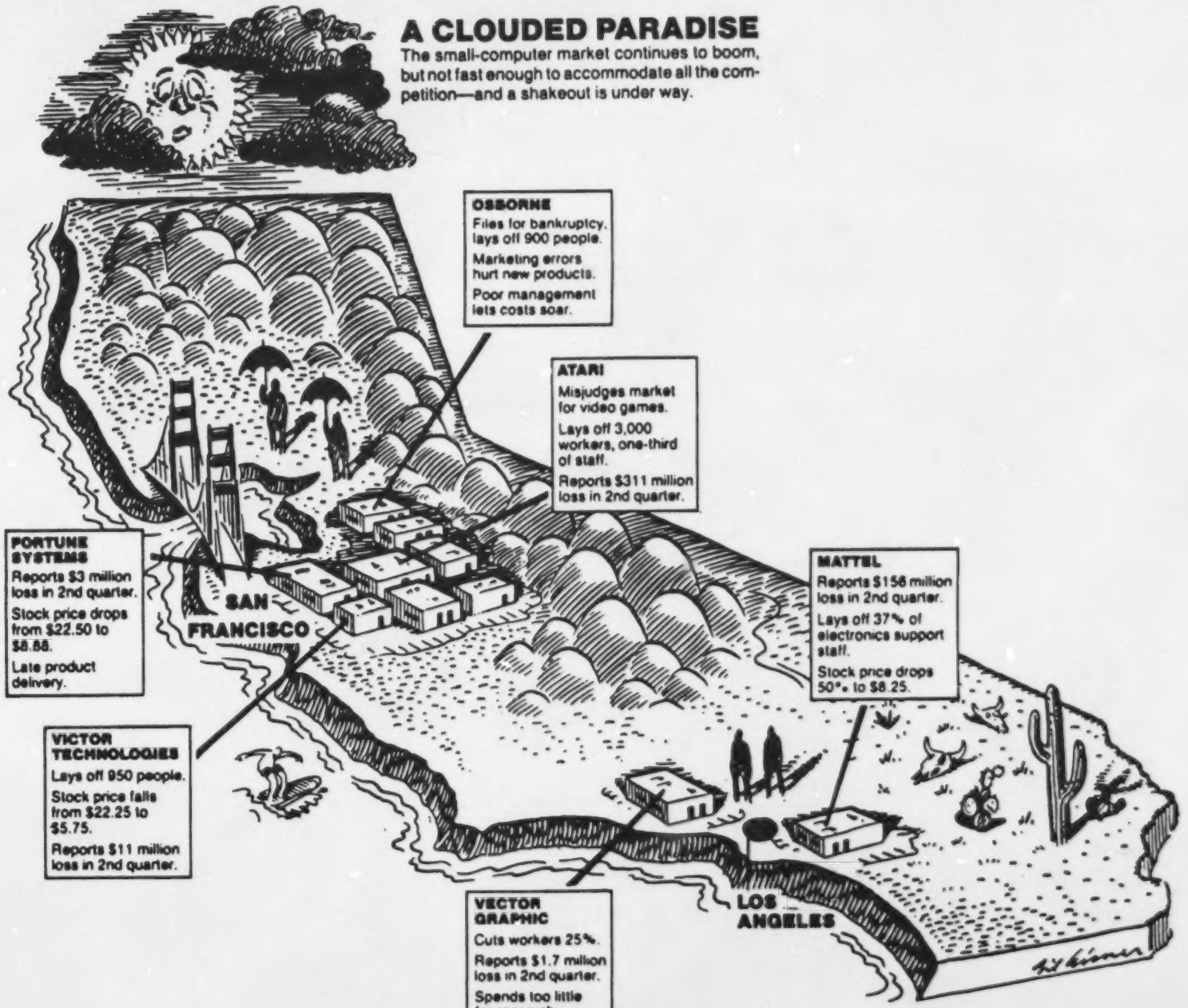
additional non-university compensation in his areas of expertise. Well educated counterparts in industry, likewise, can become instructional resources to alleviate present shortages of qualified professionals in engineering and engineering technology, with instruction delivered by electronic means.

Utilization of student and faculty "flex time" could bring interesting solutions to some of the long persisting problems plaguing engineering and engineering technology practicioners. The challenge of the engineer and the technologist has always been towards new structures and assemblages that yield higher performance, efficiencies and levels of quality in quantium increments. It should be so in education.

My suggestions to this group is not intended as an outcry against the dedicated and gifted professionals that work within our educational systems. It is intended to suggest that we became educators to teach our pupils to design and redesign for increased efficiencies, productivity and profitability in the world of technology. These is no reason that we should deny ourselves the pleasure and privilege of reshaping of current practices into new ones that provide high quality and standards on one hand and assuagement of our perplexing problems on the other.

A CLOUDED PARADISE

The small-computer market continues to boom, but not fast enough to accommodate all the competition—and a shakeout is under way.


OSBORNE
Files for bankruptcy, lays off 900 people.
Marketing errors hurt new products.
Poor management lets costs soar.
ATARI
Misjudges market for video games.
Lays off 3,000 workers, one-third of staff.
Reports $311 million loss in 2nd quarter.
FORTUNE SYSTEMS
Reports $3 million loss in 2nd quarter.
Stock price drops from $22.50 to $8.88.
Late product delivery.
SAN FRANCISCO
MATTEL
Reports $156 million loss in 2nd quarter.
Lays off 37% of electronics support staff.
Stock price drops 50% to $8.25.
VICTOR TECHNOLOGIES
Lays off 950 people.
Stock price falls from $22.25 to $5.75.
Reports $11 million loss in 2nd quarter.
VECTOR GRAPHIC
Cuts workers 25%.
Reports $1.7 million loss in 2nd quarter.
Spends too little for research.
LOS ANGELES

Communication Linked Classroom System

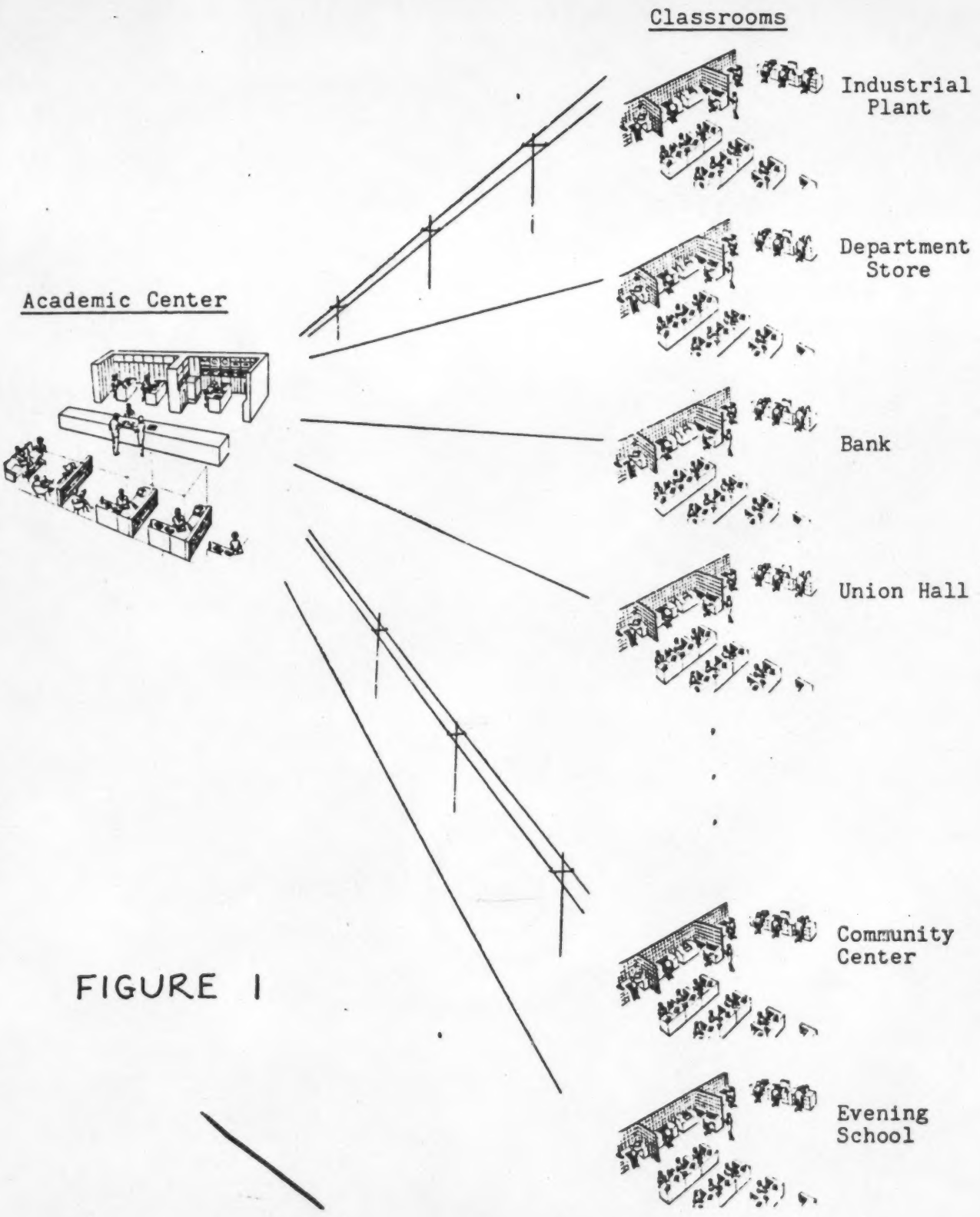


FIGURE 1

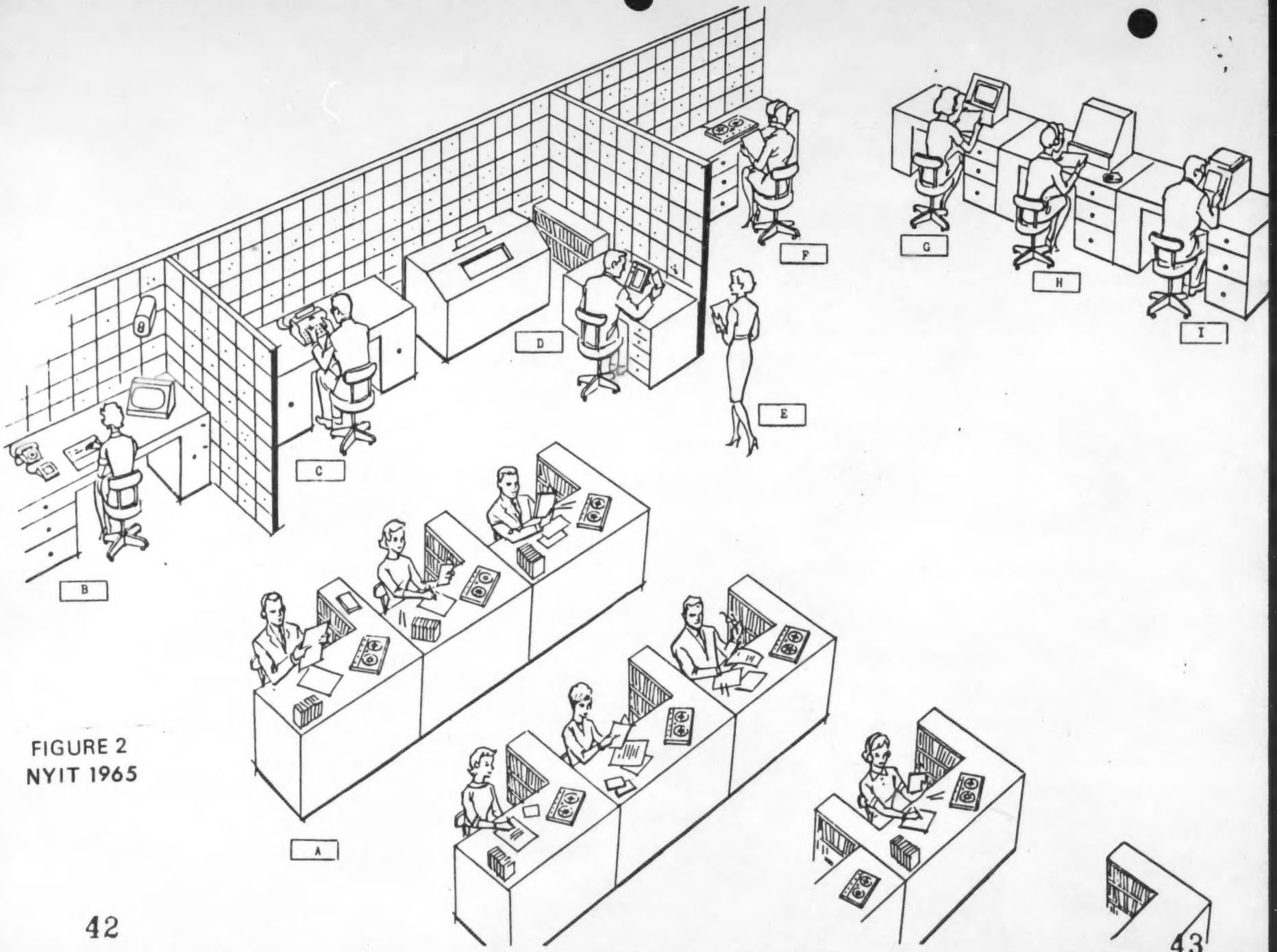


FIGURE 2
NYIT 1965

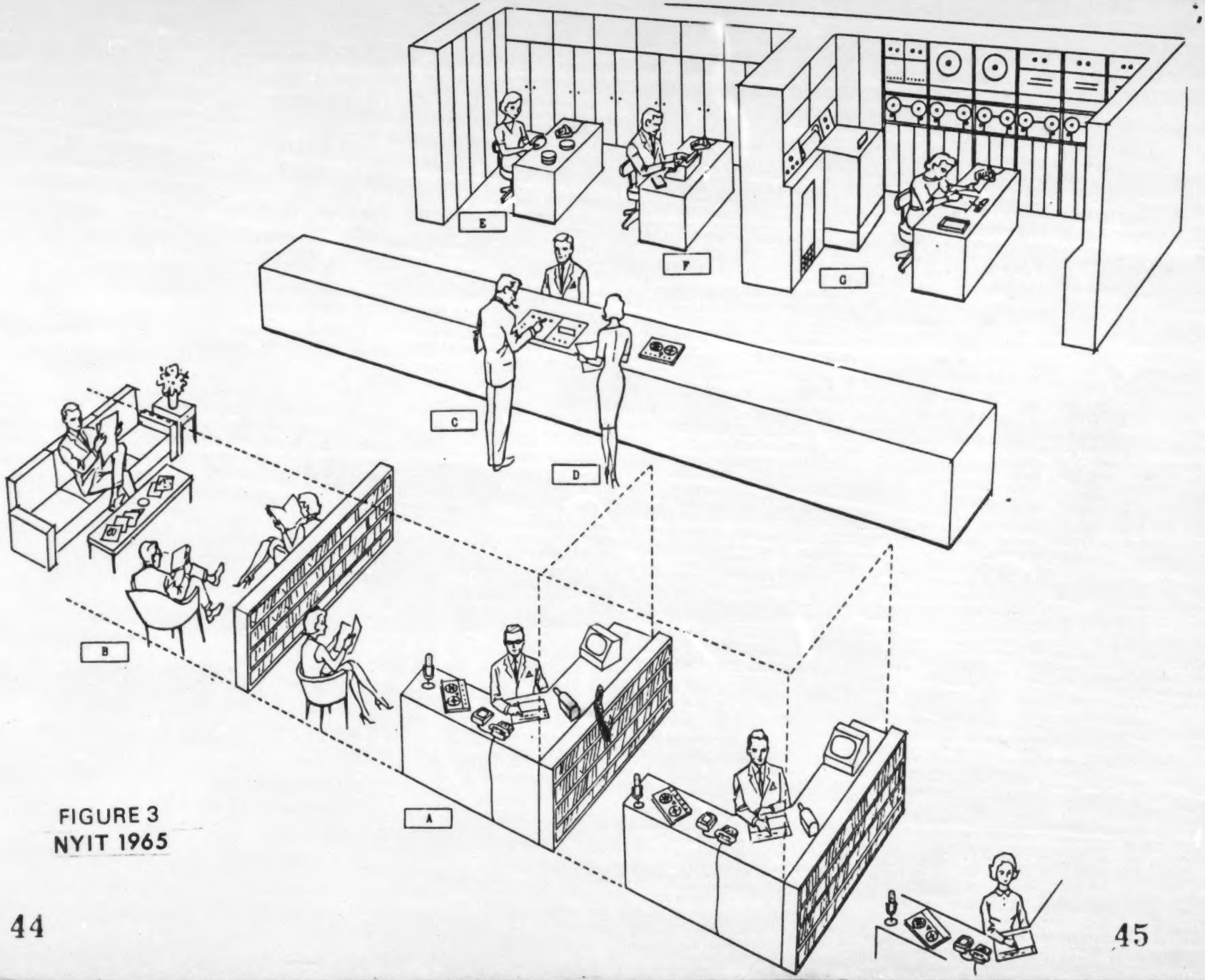


FIGURE 3
NYIT 1965